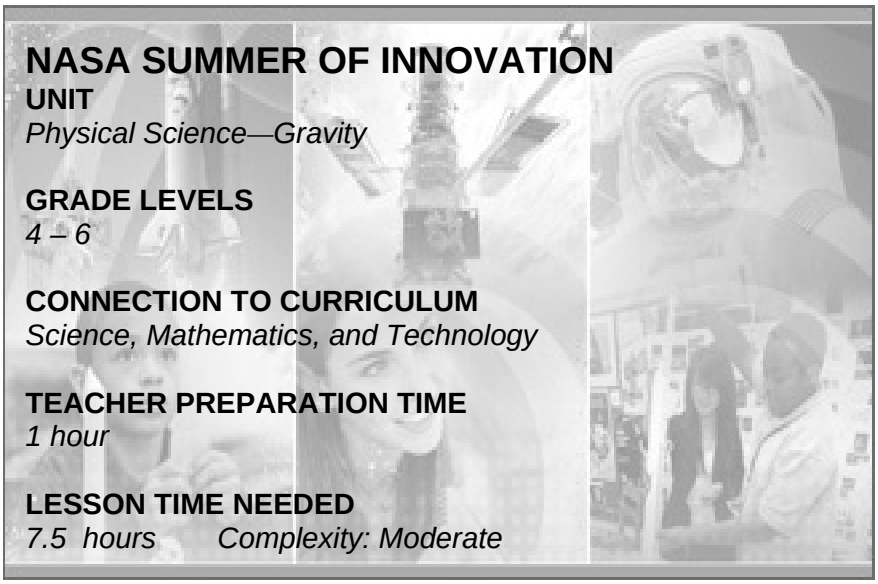
Heavy Duty Topics

DESCRIPTION
This lesson guide integrates a series of activities highlighting the difference between mass and weight.

OBJECTIVES
Students will

- Distinguish between mass and weight
- Demonstrate the use of an inertial balance
- Evaluate the effect of mass and string length on the period of a pendulum



NASA SUMMER OF INNOVATION

UNIT
Physical Science—Gravity

GRADE LEVELS
4 – 6

CONNECTION TO CURRICULUM
Science, Mathematics, and Technology

TEACHER PREPARATION TIME
1 hour

LESSON TIME NEEDED
7.5 hours *Complexity: Moderate*

NATIONAL STANDARDS

National Science Education Standards (NSTA)
Science as Inquiry
• Skills necessary to become independent inquirers about the natural world
Physical Science
• Motions and forces
• Transfer of energy
Science in Personal and Social Perspectives
• Science and technology in society

Common Core State Standards for Mathematics (NCTM)
Number and Operations
• Perform operations with multidigit whole numbers and with decimals to hundredths
Measurement and Data
• Represent and interpret data
Expressions and Equations
• Reason about and solve one-variable equations and inequalities

ISTE NETS and Performance Indicators for Students (ISTE)
Creativity and Innovation
• Use models and simulations to explore complex systems and issues

MANAGEMENT
Groups of three to four students are recommended for all activities. Build the falling weight apparatus and inertial balances prior to class time. Make sure to have a soft landing area for all falling weights. The Mass versus Weight activities have accompanying videos which should be viewed after each activity. You may want to download these prior to the activity.

CONTENT RESEARCH

The force of gravity between two objects depends upon the mass of each object and the separation between their centers of mass. When one mass is significantly larger than the other, we refer to the force of gravity as the smaller object's weight. This makes weight an extrinsic property while mass is an intrinsic property. Mass is measured in kilograms or slugs while weight is measured in Newtons or pounds.

Key Terms:

- **Gravity:** the attractive force between any two massive objects
- **Inertia:** the tendency of an object to maintain its state of motion.
- **Weight:** a measure of the pull of gravity on an object
- **Mass:** the amount of material present in an object or a measure of the inertia of an object
- **Period:** the amount of time needed for one complete periodic motion
- **Periodic motion:** motion pattern which repeats in time such as back and forth swing of a pendulum

Misconceptions:

Students often believe that mass and weight are interchangeable. Since weight depends upon mass and distance between objects, they are not equivalent. Students also often believe that once in orbit, gravity has no effect. Orbit exists because gravity constantly changes the direction of an object which is moving at right angles to the pull of gravity.

LESSON ACTIVITIES

The suggested sequence starts by introducing students to the concept of microgravity then the distinction between mass and weight, and ends with a method of determining mass in the microgravity environment.

Falling Weight Apparatus

Students use a simple apparatus to explore the difference between gravity and microgravity.
http://www.nasa.gov/pdf/315956main_Microgravity_in_the_Classroom.pdf

Mass vs. Weight

Students perform a series of experiments and compare their results to those of astronauts on the International Space Station. Stretching mass, air-powered mass, and accelerating mass are the most relevant activities to this lesson.
http://education.ssc.nasa.gov/massvsweight.asp

Pendulums

Students explore the effect of mass and string length on the period of a pendulum.
Pendulum Activity

Inertial Balance

Students calibrate an inertial balance and then use it to determine an unknown mass.
http://www.nasa.gov/pdf/315957main_Microgravity_Inertial_Balance.pdf

MATERIALS

- 2 pieces of wood 16"x2"x1"
- 2 pieces of wood 10"x2"x1"
- Wood screws
- 8 corner brace triangles
- Glue
- Screw eyes
- Rubber bands (size 19)
- Fishing sinkers
- Sewing needle
- Small round balloons
- String
- Full liquid drink pouch and empty liquid drink pouch (1 set per group)
- Mass scale
- Scissors
- 30 cm ruler (1 per group)
- Tape
- Safety goggles
- Mass car template on cardstock (1 per group)
- 4 oz drinking cup (1 per group)
- 15 straight straws cut in half (1 set per group)
- Party balloon air pump (1 per group)
- Meterstick (1 per group)
- Graph paper
- 15 pennies (1 set per group)
- Tape measure (12' with spring release and lock button) (1 per group)
- Stop watch (1 per group)
- Washers (20 per group)
- Ring or support stand
- C clamp
- Paper clips
- 2 Film canisters or similar small container with lid (1 set per group)
- Hacksaw blade (1 per group)
- 2 Wood blocks (1 set per group)
- Duct tape

ADDITIONAL RESOURCES
Video on the importance of microgravity in research
http://www.nasa.gov/mov/196820main_055_Role_of_Microgravity.mov

DISCUSSION QUESTIONS
Each activity includes questions for discussion.
Additional questions:

- Why would NASA scientists study need to know the mass of an object in orbit? *It is the measure of how much material is present and therefore helps define the object*
- Can you weigh a planet? *Yes by looking at its motion around its star or measuring its force of gravity on a known mass*

ASSESSMENT ACTIVITIES
Each activity has a series of questions in the student pages.
Pretest/Posttest questions:

- What is weight? *A measure of the force of gravity on an object*
- What is mass? *A measure of the inertia of an object or the amount of material in an object*
- What does an inertial balance measure, mass or weight? *Mass*
- What is the effect of string length on a pendulum? *There is no effect*

ENRICHMENT

- Have students research careers and build their own experiment activities from the Mass vs. Weight site.
- Have students calculate their weight on other planets.